

# Geospatial Technology Competency Model - Tiers 1-5

*Items in Green are referenced in GTCM Assessment Tool*

## Tier 1 – Personal Effectiveness Competencies

### 1. Interpersonal Skills: Demonstrating the ability to work effectively with others.

Interact appropriately and respectfully with supervisors and coworkers  
Work effectively with people who have diverse personalities and backgrounds  
Respect the opinions, perspectives, customs, and individual differences of others  
Use appropriate strategies and solutions for dealing with conflicts and differences to maintain a  
Be flexible and open-minded when dealing with a wide range of people  
Listen to and consider others' viewpoints

### 2. Integrity: Displaying accepted social and work behaviors.

Treat others with honesty, fairness, and respect  
Respect the morals and beliefs of society  
Take responsibility for accomplishing work goals within accepted timeframes  
Accept responsibility for one's decisions and actions

### of one's profession.

Stay calm, think clearly, and act decisively in stressful situations  
Accept criticism and attempt to learn from mistakes  
Demonstrate a positive attitude towards work  
Strengthen your profession by mentoring junior colleagues and championing continuing  
Follow rules and standards of dress and personal hygiene  
Refrain from substance abuse

### 4. Initiative: Demonstrating gumption at work.

Take initiative in seeking out new responsibilities and work challenges  
Pursue work with energy, drive, and effort to accomplish tasks  
Persist at a task despite interruptions, obstacles, or setbacks  
Establish and maintain personally challenging but realistic work goals  
Strive to exceed standards and expectations

### 5. Dependability and Reliability: Displaying responsible behaviors at work.

Behave consistently, predictably, and reliably  
Fulfill obligations, complete assignments, and meet deadlines  
Follow written and verbal directions  
Comply with organizational rules, policies, and procedures

### 6. Lifelong Learning: Displaying a willingness to learn and apply new knowledge and skills.

Demonstrate an interest in personal and professional lifelong learning and development  
Treat unexpected circumstances as opportunities to learn and adopt new techniques  
Seek feedback, and modify behavior for improvement  
Broaden knowledge and skills through job shadowing and continuing education  
Use newly learned knowledge and skills to complete specific tasks  
Take charge of personal career development by identifying personal interests and career pathways  
Seek and maintain membership in professional associations  
Read technical publications to stay abreast of new developments in the industry  
Maintain certifications and continuing education credits

## Tier 2 – Academic Competencies

### 1. Reading: Understanding written sentences and paragraphs in work-related documents.

Locate, understand, and interpret written technical and non-technical information in documents such as charts, graphs, manuals, maps, memos, records, reports, schedules, surveys, tables, and titles

Evaluate and analyze written materials critically, synthesizing information from multiple sources

Discriminate reliable from unreliable sources

Identify relevant details, facts, and main ideas

Infer or locate meaning of unknown or technical vocabulary

Understand the essential message and purpose of written materials

### 2. Writing: Using standard English to create work-related documents.

#### Organization and Development

Create documents such as case studies, charts, contracts, designs, diagrams, directions, graphs, legal descriptions, letters, manuals, maps, plans, records, reports, and surveys

Communicate thoughts, ideas, information, messages, and other written information, which may contain technical material, in a logical, organized, coherent, and persuasive manner

Develop ideas with supporting information and examples

#### Mechanics

Use standard syntax and sentence structure

Use correct spelling, punctuation, and capitalization; use appropriate grammar (e.g., correct tense, Write in a manner appropriate for business; use language appropriate for the target audience; avoid unnecessary jargon; use appropriate tone and word choice (e.g., writing is professional & courteous)

Avoid plagiarism by paraphrasing, citing, and referencing sources properly

### 3. Mathematics: Using the principles of mathematics to solve problems.

Know and apply mathematical principles:

Number Systems and Relationships – whole numbers, decimals, fractions, and percentages

Number Operations and Computation – addition, subtraction, multiplication, and division

Measurement and Estimation – measurement of time, temperature, distances, length, width, height, perimeter, area, volume, weight, velocity, and speed; unit conversion; numerical analysis to obtain

Mathematical Notation – the language of mathematics to express mathematical ideas

Mathematical Reasoning and Problem Solving – inductive and deductive reasoning, conjectures, Statistics and Probability – standard deviation, variance, tests of significance, sampling, probability, Algebra – equations, patterns, functions, 3D vectors, and matrices

Geometry – size, shape, and position of figures; using geometric principles to solve problems

Trigonometry – relationships among the sides and angles of triangles on planes and spheres

**where things are located on the surface of the earth, why they are located where they are, how places differ from one another, and how people interact with the environment.**

Know and apply geographic skills, including:

#### Subject-specific Geographic Knowledge

Human-Environment Interaction: Know and apply geographic information about relationships between nature and society (e.g., pollution from industrial development, economic effects of

Regional Geography: Know and apply knowledge of the physical and human geography of a specific

Physical Geography: Know and apply geographic information about the processes that shape physical landscapes; weather, climate and atmospheric processes; ecosystems and ecological

Cultural Geography: Know and apply geographic information about culture and cultural processes, including religion, language, ethnicity, diffusion, meaning of landscapes, cultural significance of

## **Geographic Skills**

Geographic Information Systems (GIS): Use GIS to acquire, manage, display, and analyze spatial

Cartography: Producing, creating, and designing paper or digital maps

Field Methods: Use interviews, questionnaires, observations, photography, maps, GPS, GIS, and other techniques to measure geographic information in the field

Spatial Statistics: Use quantitative methods to process spatial data for the purpose of making calculations, models, and inferences about space, spatial patterns, and spatial relationships

## **Geographic Perspectives**

Spatial Thinking: Identify, explain, and find meaning in spatial patterns and relationships, such as site conditions, how places are similar and different, the influence of a land feature on its neighbors,

Global Perspective: Possess and apply knowledge of how people, places, and regions are linked by global networks and processes (e.g., globalization, international trade, immigration, Internet

Interdisciplinary Perspective: Draw on and synthesize the information, concepts, and methods of the natural and social sciences for geographic research and applications

## **and engineering to solve problems.**

Scientific knowledge and methods:

**Scientific Method** – the systematic pursuit of knowledge involving the recognition and formulation of a problem, the collection of data through observation and experiment, and the formulation and

### **Subject-specific Scientific Knowledge**

Physical Sciences, including Agricultural Science – production of goods through the growing of plants, animals, and other life forms; Biology – the phenomena of life and living organisms;

Environmental Science/Ecology – the relationships between organisms and their environments;

Forestry – the cultivation, maintenance, and management of forests; Geology – the origin, history, and structure of the earth; Hydrology – properties, distribution, and effects of water on the Earth's

surface; Meteorology and Climatology – phenomena of the atmosphere, especially weather and

Social sciences, including Anthropology – the origins and social relationships of human beings;

Demography – the characteristics of human populations; Economics – the production, distribution and consumption of goods and services and their management; History – the interpretation of past events involving human beings; Political Science – the government of states and other political units;

Engineering knowledge and methods:

### **Engineering Methods**

Design – design techniques, tools, and principles involved in production of precision technical plans,

Engineering technologies, including computer-aided engineering and drafting, site surveying,

### **Subject-specific Engineering Knowledge**

Architecture and Architectural Engineering – design and construction of buildings; Civil Engineering – design and construction of public and private works, such as infrastructure (roads, railways, water supply and treatment), bridges, and buildings; Environmental Engineering – application of science and engineering principles to improve the environment; Landscape Architecture – design of outdoor and public spaces

## **6. Communication – Listening and Speaking: Giving full attention to what others are saying and speaking in English well enough to be understood by others.**

### **Listening**

Receive, interpret, understand, and respond to verbal messages and other cues

Give full attention to what other people are saying, take time to understand the points being made, ask questions as appropriate, and refrain from interrupting at inappropriate times

Pick out important information in verbal messages

### **Speaking and Presenting**

Speak clearly and confidently using common English conventions including proper grammar, tone, Express information to individuals or groups taking into account the audience and the nature of the information (e.g., explain technical concepts to non-technical audiences) proposed ideas

#### **7. Critical and Analytical Thinking: Using logic, reasoning, and analysis to address problems.**

Use logic and reasoning to identify strengths and weaknesses of alternative solutions, conclusions, or  
Use inductive and deductive reasoning to analyze, synthesize, compare, and interpret information  
Draw conclusions from relevant or missing information  
Understand the underlying relationship among facts and connections between issues  
Organize problems into manageable parts

#### **information.**

#### **Navigation and File Management**

Use scroll bars, a mouse, and dialog boxes to work within the computer's operating system  
Access and switch between applications and files of interest

#### **Internet and E-mail**

Navigate the Internet to find information  
Open and configure standard browsers  
Use searches, hypertext references, and transfer protocols  
Send and retrieve electronic mail (e-mail)  
Write e-mail with an appropriate tone  
Manage personal schedule and contact information  
Navigate the Internet to find and attend online training, web conferences, webinars, self-paced  
Employ collaborative/groupware applications to facilitate group work

#### **Writing and Publishing Applications**

Use a computer application to compose text and insert graphics  
Format, edit, and print text  
Save and retrieve word processing documents

#### **Spreadsheets**

Use a computer application to enter, manipulate, and format text and numerical data  
Insert, delete, and manipulate cells, rows, and columns  
Create and save worksheets, charts, and graphs

#### **Presentations**

Use a computer application to create, manipulate, edit, and present digital representations of

#### **Databases**

Use a computer application to manage large amounts of information  
Create and edit simple databases

#### **Input data**

Retrieve detailed records using a query language  
Create reports to communicate the information

#### **Graphics**

Work with pictures in graphics programs or other applications  
Choose and create graphs, diagrams, and other information graphics that most effectively and  
Insert graphics into other files/programs

### **Tier 3 – Workplace Competencies**

## **1. Teamwork: Working cooperatively with others to complete projects.**

Accept membership in the team and identify with its goals  
Determine when to be a leader and when to be a follower depending on what is needed to achieve  
Identify roles of team members and effectively communicate with all members of the team  
Collaborate with others to formulate team objectives and develop consensus for best outcome  
Use teamwork skills to achieve goals, solve problems, and manage conflict  
Give and receive feedback constructively  
Be open to considering new ways of doing things and the merits of new approaches to work

## **2. Creative Thinking: Recognizing, exploring, and using a broad range of ideas and practices.**

Employ unique analyses and generate original, innovative ideas and solutions in complex areas  
See the possibilities of “what can be” and inspire a shared sense of purpose within the organization  
Entertain wide-ranging possibilities to develop unique approaches and useful solutions  
Understand the pieces of a system as a whole and possess a big picture view of the situation  
Integrate seemingly unrelated information to develop creative solutions available

## **accomplish assigned tasks.**

### **Planning and Organizing**

Approach work in a methodical manner  
Apply effective organizational skills  
Break down large problems into more manageable component tasks  
Develop and implement a plan for a project  
Keep track of details to ensure work is performed accurately and completely  
Find new ways of organizing or planning work to accomplish tasks more efficiently

### **Adaptability and Flexibility**

Change gears in response to unpredictable or unexpected events, pressures, situations, and job  
Effectively change plans, goals, actions, or priorities to deal with changing situations  
Compare actual and ideal performance in order to identify performance gaps or opportunities

### **Time Management**

Develop a timeline for sequencing the activities of a project  
Establish specific goals to accomplish work in a timely manner  
Prioritize various competing tasks and perform them efficiently according to their urgency  
Ensure that others receive needed materials in time  
Stay on schedule  
Keep all parties informed of progress and all relevant changes to project timelines

## **generating, evaluating, and implementing solutions.**

### **Identify the Problem**

Anticipate or recognize the existence of a problem  
Identify the nature of the problem by analyzing its component parts and defining critical issues  
Locate, obtain, and review information relevant to the problem

### **Generate Alternatives**

Generate a variety of approaches to the problem  
Think creatively to develop new ideas for and answers to work related problems  
Use logic and reasoning to identify the strengths and weaknesses of alternative solutions,  
Build models to conceptualize and develop theoretical and practical frameworks

### **Choose and Implement a Solution**

Decisively choose the best solution after contemplating available approaches to the problem  
Commit to a solution in a timely manner

Use strategies, tools, resources, and equipment to implement the solution approaches and to identify lessons learned

**facilitate work activity.**

Identify, select, and apply tools or technological solutions appropriate to the task at hand  
Operate tools and equipment in accordance with established operating procedures and safety  
Use information technology and computer applications as it supports the gathering, storage,  
Demonstrate an interest in learning about new and emerging tools and technologies  
Identify sources of information concerning state-of-the-art tools, equipment, materials, technologies,  
Seek out opportunities to improve knowledge of tools and technologies that may assist in  
Help people adapt to the changes brought on by new technologies and helping them to see the value  
Troubleshoot and maintain tools and technologies

**6. Checking, Examining, and Recording: Entering, transcribing, recording, storing, or maintaining information in written or electronic/magnetic format.**

Compile, code, categorize, calculate, tabulate, audit, or verify information or data  
Perform with rigorous exactness and a high degree of accuracy  
Apply techniques for observing and gathering data  
Implement quality assurance and quality control procedures  
Detect and correct errors or inconsistencies, even under time pressure  
Organize records and files to maintain data

**7. Business Fundamentals: Knowledge of basic business principles, trends, and economics.**

**Economic/Business/Financial Principles**

Characteristics of Markets  
Cost and Pricing of Products  
Economic Terminology  
Fundamentals of Accounting  
Profit and Loss  
Supply/Demand

**Economic System as a Framework for Decision-making**

Quantify the costs and benefits of an information technology solution for a given organization  
Assess patterns of technologies by examining their effects on parts of an organization, as well as the effects on the organization's interactions with customers, suppliers, distributors, and workers  
Explain the relationship between individual performance and the success of the organization

**Business Ethics** – Act in the best interests of the company, your co-workers, your community,

**Legal/Financial**

Comply with the letter and spirit of applicable laws  
Use company property legitimately, minimizing loss and waste; report loss, waste, or theft of  
Maintain privacy and confidentiality of company information, as well as that of customers and co-  
Comply with intellectual property laws  
Protect trade secrets

**Environmental/Health/Safety**

Hold paramount the safety, health, and welfare of the public  
Maintain a healthful and safe environment and report any violations/discrepancies  
Ensure equipment and systems are designed to be environmentally friendly and strive to  
Practice sustainability by using processes that are non-polluting, conserving of energy and natural resources, economically efficient, that use local materials, and safe for workers, communities, and

**Social**

Emphasize quality, customer satisfaction, and fair pricing



Deal with customers in good faith; no bribes, kickbacks, or excessive hospitality  
Recognize and resist temptations to compete unfairly

### **Marketing**

Demonstrate an understanding of market trends, company's position in the market place, and  
Understand position of product/service in relation to market demand  
Uphold the company and product brand through building and maintaining customer relations  
Integrate internal and external customer demands and needs into the product

### **Entrepreneurship**

Explain the entrepreneurial process, including discovery, concept development, resourcing,  
Demonstrate skills in leadership and team building, including enlisting others to work toward a  
Discuss strategies for managing growth, including using replicable processes to create enterprises

### **Geospatial Business Fundamentals**

Discuss the historical origins of geospatial technology  
Demonstrate awareness of the various professions, agencies and firms that comprise the geospatial  
Understand the respective roles of the private sector, universities, non-profit organizations, and  
Make a business case for a given organization's investment in geospatial technology, including value  
Recognize ethical implications of bidding and other business practices in geospatial business contexts  
and make reasoned decisions about appropriate actions

## **Tier 4 – Industry-Wide Technical Competencies**

Listed in this tier are 43 examples of "Critical Work Functions" that many geospatial professionals will be expected to perform during their careers. Following the Work Functions are "Technical Content Areas" – the background knowledge upon which skills and abilities are based. These lists are exemplary, not exhaustive; geospatial professionals are called upon to demonstrate other abilities and knowledge depending on their particular roles and positions. Furthermore, few if any workers are responsible for every Critical Work Function in any one job. Thus, the examples cited represent both the core competencies of the geospatial field and the diversity of professional practice within it.

### **1. Core Geospatial Abilities and Knowledge**

#### **Critical Work Functions:**

##### **Earth Geometry and Geodesy**

Discuss the roles of several geometric approximations of the earth's shape, such as geoids, ellipsoids,  
Describe characteristics and appropriate uses of common geospatial coordinate systems, such as  
geographic (latitude and longitude), UTM and State Plane Coordinates  
Explain the relationship of horizontal datums, such as North America Datum of 1983 (NAD 83) or  
the World Geodetic System of 1984 (WGS 84), to coordinate system grids and geometric  
Describe characteristics and appropriate uses of common map projections, such as Transverse  
Mercator, Lambert Conformal Conic, Albers Conic Equal Area, Azimuthal Equidistant, and Polar

##### **Data Quality**

Discuss the elements of geospatial data quality, including geometric accuracy, thematic accuracy,  
In the context of a given geospatial project, explain the difference between quality control and quality  
Identify data quality and integration problems likely to be associated with geospatial and attribute  
Calculate and interpret statistical measures of the accuracy of a digital data set, such as Root Mean

##### **Satellite Positioning and Other Measurement Systems**

Describe the basic components and operations of the Global Navigation Satellite System (GNSS),  
including the Global Positioning System and similar systems

Explain the distinction between GNSS data post-processing (such as U.S. National Geodetic Survey's Online Positioning User Service) and real time processing (such as Real-Time Kinematic)

Collect and integrate GNSS/GPS positions and associated attribute data with other geospatial data

Compare differential GNSS and autonomous GNSS

Plan a GNSS data acquisition mission that optimizes efficiency and data quality

Identify and describe characteristics of inertial measurement systems and other geospatial

### **Remote Sensing and Photogrammetry**

Use the concept of the "electromagnetic spectrum" to explain the difference between optical sensors, microwave sensors, multispectral and hyperspectral sensors

Differentiate the several types of resolution that characterize remotely-sensed imagery, including

Explain the difference between active and passive remote sensing, citing examples of each

Acquire information needed to compare the capabilities and limitations of various sensor types in the

Explain the use of sampling ground truth data for quality assurance in remote sensing

Define "orthoimagery" in terms of terrain correction and georeferencing

### **Cartography**

Employ cartographic design principles to create and edit visual representations of geospatial data,

Demonstrate how the selection of data classification and/or symbolization techniques affects the

Critique the design of a given map in light of its intended audience and purpose

### **Geographic Information Systems**

Demonstrate understanding of the conceptual foundations on which geographic information systems (GIS) are based, including the problem of representing change over time and the imprecision and

Use geospatial hardware and software tools to digitize and georeference a paper map or plat

Acquire and integrate a variety of field data, image data, vector data, and attribute data to create,

Specify uses of standard non-spatial data models, specifically the relational data model and its

Compare advantages and disadvantages of standard spatial data models, including the nature of vector, raster, and object-oriented models, in the context of spatial data used in the workplace

Describe examples of geospatial data analysis in which spatial relationships such as distance, direction, and topologic relationships (e.g. adjacency, connectivity, and overlap) are particularly

Use geospatial software tools to perform basic GIS analysis functions, including spatial measurement, data query and retrieval, vector overlay, and raster map algebra

Demonstrate a working knowledge of GIS hardware and software capabilities, including real time

### **Programming, application development, and geospatial information technology**

Demonstrate understanding of common geospatial algorithms, such as geocoding or drive time

Recognize GIS tasks that are amenable to automation, such as route generation, incident response,

Identify alternatives for customization and automation, such as APIs, SDKs, scripting languages

Identify the information technology components of a GIS, such as databases, software programs, application servers, data servers, SAN Devices, workstations, switches, routers, and firewalls

Compare benefits and shortcomings of desktop, server, enterprise, and hosted (cloud) software

Discuss trends in geospatial technology and applications

Compare the capabilities and limitations of different types of geospatial software, such as CAD, GIS,

Recognize opportunities to leverage positioning technology to create mobile end-user applications

### **Professionalism**

Identify allied fields that rely on geospatial technology and that employ geospatial professionals

Participate in scientific and professional organizations and coordinating organizations

Demonstrate familiarity with codes of professional ethics and rules of conduct for geospatial geospatial data

**Technical Content Areas:** Headings correspond to select knowledge areas identified in the first edition



## **Conceptual Foundations**

Spatial and topological relationships

## **Geospatial Data**

Earth geometry and its approximations, including geoids, ellipsoids, and spheres

Georeferencing systems, including coordinate systems and land partitioning systems

Datums, horizontal and vertical

Map projections

Data quality, including geometric accuracy, thematic accuracy, resolution and precision

Surveying, including numerical methods such as coordinate geometry, least-squares adjustment, and

Global Navigation Satellite System, including GPS, GLONASS, Galileo, Beidou (a.k.a. Compass),

Data input, including field data collection, digitizing, scanning, and data conversion

Terrain modeling and representation

Photogrammetry

Remote Sensing, including aerial imaging, image interpretation, image processing, multispectral and hyperspectral remote sensing, and full-motion video

Metadata, standards and infrastructure

Alternative positioning technologies, such as wifi, TV, cell, and RFID.

## **Data Modeling**

Database Management Systems, including relational, object-oriented, and extensions of the relational

Data Models, including grid, raster, TIN, hierarchical, topological, vector, network, and object-

Geospatial data compression methods

Data archiving and retrieval

## **Design Aspects**

Conceptual Models

## **Analytical Methods**

Geometric Measures

Overlay Analysis

Viewshed Analysis

Network Analysis

## **Cartography and Visualization**

Principles of Map Design, including symbolization, color use, and typography

Graphic Representation Techniques, including thematic mapping, multivariate displays, and web

Data Considerations for Mapping, including source materials, data abstraction (classification,

Map Production

## **GIS&T and Society**

Legal issues, including property rights, liability, and public access to geospatial information.

Ethical issues, including privacy, geographic profiling, and inequities due to the “digital divide”

Codes of ethics for geospatial professionals

## **Organizational and Institutional Aspects**

Professional, scientific and trade organizations, such as AAG, ACSM, ASPRS, GITA, MAPPS, NSGIC,

Professional certification and licensing bodies, including GISCI, ASPRS and NCEES

Federal agencies, such as U.S. Geological Survey, U.S. Census Bureau, National Geospatial-

International organizations, such as GSDI, ISPRS, and ICA

Publications, including scholarly journals, trade magazines, and blogs

State and regional coordinating bodies, such as NSGIC and state Geographic Information Offices

Standards organizations, such as FGDC and OGC

## Tier 5 – Industry Sector Technical Competencies

each of three industry sectors: (1) Positioning and Geospatial Data Acquisition; (2) Analysis and Modeling; and (3) Software and Application Development. The sectors represent clusters of worker competencies associated with three major categories of geospatial industry products and services. The Critical Work Functions listed for each sector are exemplary rather than exhaustive, representing the diversity of professional practice in the geospatial field. The responsibilities of many individual geospatial professionals span two or even three sectors. However, few if any workers are responsible

geospatial industry revenues. In the U.S., Federal, state, and local government agencies are major consumers, but utilities, telecommunications firms, and other geographically-extensive organizations also rely on up-to-date geospatial data for their business operations. Workers in this sector are expert in the unique geometric and thematic properties of geospatial data, and are especially knowledgeable about the factors that affect data quality. They know how various data production technologies work—including the Global Navigation Satellite System (GNSS—and its component technologies such as GPS), airborne and satellite-based sensors, photogrammetric instruments, surveying instruments, real time GPS/GIS mapping systems, and other field data collection devices—and know how to deploy them to meet project requirements. Others are expert in field data collection, qualitative survey methods, administrative records and databases, and other data capture methods and technologies used to collect georeferenced observations and measurements. In addition to traditional modes of capturing data through remote sensing, surveying, and other field-based methods, this sector includes newer modes that incorporate the positioning capabilities of mobile phones and in-car navigation systems, as well as volunteered geospatial data gathered from social media and Internet technologies. Despite

### Critical Work Functions:

Use specialized geospatial software to transform ellipsoid, datum, and/or map projection to georegister one set of geospatial data to another

Geocode a list of address-referenced locations to map data encoded with geographic coordinates and

Discuss examples of systematic and unsystematic land partitioning systems in the U.S. and their

Compare how land records are administrated in the U.S. in comparison with other developed and

Explain the distinction between a property boundary and its representations, such as deed lines, lines on imagery, boundary depictions in cadastral (land records) databases

Plot a legal boundary description from a deed or plat

Design an integrated measurement system solution for acquiring and processing geospatial data

Identify sampling strategies for field data collection, including systematic, random, and stratified random sampling, and describe circumstances favorable to each

Explain how spatial autocorrelation influences sampling strategies and statistics

Perform requirements analysis for remotely sensed data acquisition using resolution concepts

Explain the concept of “bit depth” and its implications for remotely-sensed image data

Plan a remotely sensed data acquisition mission, including specifying an appropriate sensor and platform combination suited for particular project requirements

Illustrate the differences between ellipsoidal (or geodetic) heights, geoidal heights, and orthometric

Make and justify a choice between Real time Standard Positioning Service (SPS) and Real time

Perform GNSS data post-processing (such as National Geodetic Survey’s Online Positioning Service)

Collect and integrate carrier phase (survey grade) GNSS positions and associated attribute data with

Explain GNSS data quality issues, such as multipath, PDOP, and signal-to-noise ratio

Explain major GNSS error sources, such as ionospheric delay, clock error, ephemerides, and satellite

Produce an orthoimage data product with geometric accuracy suitable for project requirements

Describe the components and operation of an aerotriangulation system

Produce a metadata document that conforms to a geospatial metadata standard

Design a questionnaire and interview protocol for acquiring georeferenced socio-economic data

Diagram the sequence of functions involved in producing georeferenced textual information

million property parcels in the U.S.

**Technical Content Areas:** Headings correspond to select knowledge areas identified in the first edition

### Geospatial Data

Earth Geometry

Land Partitioning Systems, including metes and bounds, USPLS, and long lots

Georeferencing Systems, including coordinate systems

Datums

Map Projections

Data Quality

Land Surveying

Global Navigation Satellite System

Field Data Collection

Photogrammetry

Remote Sensing

Metadata, standards and infrastructures

software, many of whom are employed in geospatial occupations within allied industries (such as those identified in the Technical Content Areas section below, under Organizational and Institutional Aspects). Successful practitioners in this sector know when and how to employ analytical functions of geospatial software tools to render valid and reliable information from geospatial data. Many are fluent with both data-driven “exploratory” analyses as well as model-driven analyses for hypothesis testing and prediction. Some analysts specialize in designing and implementing geospatial databases that

### Critical Work Functions:

Describe an example of a useful application of a buffer operation in GIS software

Perform a site suitability analysis using intersection and overlay functions of GIS software

Use GIS software to identify an optimal route that accounts for visibility, slope, and specified land

Perform dynamic segmentation on transportation network data encoded in a linear reference system

Explain how leading online routing systems work, and account for common geocoding errors

Use location-allocation software functions to locate service facilities that satisfy given constraints

Develop conceptual, logical, and physical models of a geospatial database designed in response to

Explain the Modifiable Areal Unit Problem in relation to the “ecological fallacy”

Compare characteristics and appropriate uses of geospatial modeling techniques, such as neural networks, cellular automata, heuristics, agent-based models, and simulation models such as Monte

Assess the current state of the art in coupling predictive models and simulations with GIS software

Employ cartographic techniques to represent different kinds of uncertainty, including uncertain boundary locations, transitional boundaries, and ambiguity of attributes

Establish, re-establish and/or monument property boundaries; represent such boundaries in plats, records, and descriptions, all under personal and professional liability as stipulated in legal statute

Define the sampling theorem in relation to the concept of spatial resolution of remotely-sensed

Determine appropriate image data and image analysis techniques needed to fulfill project

Outline workflows that identify sequence of procedures involved in geometric correction, radiometric correction, and mosaicking of remotely sensed data

Explain how to quantify the thematic accuracy of a land use/land cover map derived from remotely-

Evaluate the thematic accuracy of a data product derived from aerial image interpretation, such as a  
Explain the difference between pixel-based and object-based image classification  
Perform object-oriented image classification using specialized software tools

**Technical Content Areas:** Headings correspond to select knowledge areas identified in the first edition

**Analytical Methods**

Basic Analytical Operations, such as buffers, overlay, neighborhoods, and map algebra  
Basic Analytical Methods, such as point pattern analysis, spatial cluster analysis, multi-criteria  
Analysis of Surfaces, including interpolation of surfaces, surface features, and viewshed analysis  
Geostatistics, including spatial sampling, semi-variogram modeling, and kriging  
Data Mining, including pattern recognition  
Network Analysis, including least-cost paths, flow modeling, and accessibility modeling

**Design Aspects**

Analysis Design

**Data Modeling**

Database Design

**Geocomputation**

Neurocomputing  
Cellular Automata Models  
Heuristics  
Genetic algorithms  
Agent-based Models  
Simulation Models  
Uncertainty

**Geospatial Data**

Land Surveying  
Field Data Collection  
Remote Sensing, including algorithms and processing

**Cartography and Visualization**

Graphic Representation Techniques, including dynamic and interactive displays, Web mapping and

**GIS&T and Society**

Ethical Aspects, including obligations to individuals, to employers and clients, to colleagues and the  
Legal Aspects, including liability

**Organizational and Institutional Aspects**

Allied industries in which professionals need to understand geographic principles, such as  
Agribusiness; Economic Development; Military/Intelligence; Homeland Security; Emergency  
Management & E911; Environmental and Natural Resources; Forestry; Coastal and Marine Resources  
Management; Real Estate and Land Management; Telecommunications; Energy, Exploration and  
Mining; Utilities (Public and Private) and Power Generation; City, State, County, Provincial and  
other Local Government; Transportation and Logistics (Fleet Management, Mobile Resource  
Management, Road and Highway Planning and Maintenance); Urban and Regional Planning; Mobile  
Location-Based Services and Communication (Navigation. Location-based alerts. Location-based  
Allied industries in which geographic information is a crucial part of many job functions, including  
Advertising, Marketing and Market Research; Architecture, Engineering and Construction; Banking  
and Finance; Insurance; Cultural Resource Management; Health Care; Education; Journalism and  
Publishing; Law Enforcement; Manufacturing; Politics and Elections; Public Safety and Health;  
Restaurants and Food Service; Entertainment; Retail; Tourism

earned in the geospatial industry. Geospatial software products vary from full-featured GIS software products, to specialized applications targeted to the needs of particular user communities, to component toolkits used by developers to create specialized end-user applications. Software products also include applications for processing, analysis, or adding value to remotely sensed data. In addition to workers employed by commercial software development firms, many geospatial professionals in diverse settings create specialized software applications to automate routine tasks and to customize end-user interfaces. Increasingly common is non-professional development of customized map “mashups” based on online

### **Critical Work Functions:**

- Develop use cases for user-centered requirements analyses
- Perform a feasibility study and cost/benefit analysis
- Design a geospatial system architecture that responds to user needs, including desktop, server, and
- Communicate effectively with end-users to ensure that software applications meet user needs
- Optimize geospatial system performance
- Identify appropriate software development tools for particular end uses
- Create geospatial software programs using programming languages such as C, C++, and Java
- Ensure that software code complies with industry standards, such as those promulgated by the Open
- Identify the factors that affect the interoperability of geospatial software applications
- Automate geospatial analysis methods such as transformations, raster analysis, and geometric
- Use scripting languages such as Python and others to automate repetitive tasks in desktop geospatial
- Customize geospatial software using proprietary and open source software components, such as ESRI’s ArcObjects, Intergraph’s GeoMedia software suite, and the GeoTools open source project
- Use scripting languages such as JavaScript, PHP, and KML to create web mapping applications
- Employ query languages such as SQL to interrogate spatial databases
- Work effectively in teams to plan and coordinate software and application development
- Stay informed about trends and best practices in information technology and software engineering, such as unit testing, version control, and continuous integration
- Evaluate open source software components for re-use and potential return contributions
- Realize opportunities to leverage positioning technology to create mobile end-user applications
- Explain how geospatial software in large enterprises fits into SOA (Service Oriented Architectures)
- Be able to leverage new architectural opportunities such as cloud computing

**Technical Content Areas:** Headings below correspond to select knowledge areas identified in the First Edition of the *GIS&T Body of Knowledge* (UCGIS 2006). Professionals who work in this sector are also responsible for knowledge areas defined in bodies of knowledge of the Computer Science, Software

### **Analytical Methods**

- Structured Query Language
- Spatial Queries

### **Design Aspects**

- System Design
- Project Definition
- Resource Planning
- Database Design
- Analysis Design
- Application Design
- System Implementation

## **Tiers 6-9 – Occupation-Specific Competencies and Requirements**



The GTCM specifies competencies required for success in the geospatial industry, from the most general “Personal Effectiveness Competencies” (Tier 1) to the sector-specific competencies presented in Tier 5. Beyond the scope of this document are knowledge areas and technical competencies associated with particular occupations (Tiers 6 and 7) and with particular occupational requirements, such as licensure and certification (Tier 8). Occupation-specific competencies are identified in the Department of Labor’s Occupational Information Network database (<http://online.onetcenter.org/>), in an ongoing series of DACUM occupational analyses performed by the National Geospatial Technology Center (<http://www.geotechcenter.org>), and in employers’ job descriptions. Requirements for licensure and

Employment and Training Administration  
United States Department of Labor, [www.doleta.gov](http://www.doleta.gov)

Jjohnson, 9-2011, National GeoTech Center